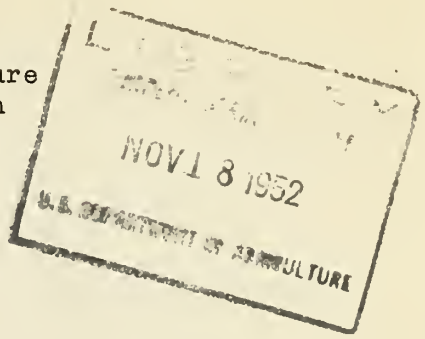
United States Department of Agriculture
Agricultural Research Administration
Bureau of Plant Industry, Soils,
and Agricultural Engineering




H. T. & S. Office Report No. 282

# Rail Refrigeration Tests with Florida Citrus
## A Comparison of Refrigerator Cars

By

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October, 1952
Orlando, Florida

# RAIL REFRIGERATION TESTS WITH FLORIDA CITRUS

## A Comparison of Cars

### Introduction

This is the fourth in a series of reports on shipping tests with Florida citrus fruits issued during the current year.

The first three reports, viz., H.T.&S. Reports Nos. 277, 279, and 280, gave an accounting of accompanied tests conducted in November 1950, April and May 1951, respectively, in which a comparison of protective services was the main objective. The present report is concerned with a comparison of types of cars in relation to temperatures in transit obtained in two unaccompanied tests. The first and second tests consisted of three and four cars loaded December 13, 1945 and March 28, 1946.

On both occasions the standard end bunker fan car (with fans under the floor rack) was compared with the overhead bunker car, both being comparatively new departures from the conventional end bunker car without fans, also included. In the second test, a double deck end bunker car without fans was added.

The transit temperatures were obtained by recording thermometers placed in the center of containers located along the centerline of the car at the following points: 1) bottom bunker, the coldest location in end bunker cars, 2) middle quarterlength, where mean temperatures are found in such cars, and 3) the top doorway position, the warmest location. In the second test, a fourth thermograph was placed at the top quarterlength position. These locations should give the range of load temperatures likely to be found in refrigerator cars. The outside air temperatures during transit were recorded by a thermograph placed beneath one of the cars.

The first test was loaded at Wabasso and Fort Pierce, December 13, the loads in non-fan car being completed by 9:00 a.m., in the fan car by 11:00 a.m., and in the overhead bunker car by 6:00 p.m. The lading was precooled grapefruit in nailed crates, and each car was re-iced but once, at Waycross, under the free icing service, Item 80, Section 2, the equivalent of Rule 251. These cars were unloaded during the morning of December 18.

The maximum outside air temperatures reached the day of loading were 79°, with the following temperatures, minimum and maximum, recorded during transit: first day, 61°-79°; second, 47°-67°; third, 23°-47° and fourth day, 13°-25°.

Average Commodity Temperatures - The commodity temperatures, Figures 1, 2 and 3, during loading averaged 67°, 69° and 73° in non-fan, fan and overhead bunker cars respectively. Upon arrival at the New York City area four nights after loading, the average temperatures in these cars were 41°, 39° and 47° respectively, and upon unloading, the following night, they were 38°,

38° and 43° respectively. The lowest average temperature during transit was in the fan car and the highest in the overhead bunker car. The warmest level was in the top of the load in the non-fan cars and in the middle of the fan car.

Temperature Spread - The greatest spread in temperatures during transit was in the end bunker non-fan car, with a range of 16 degrees the first midnight after loading and 22, 19, 17 and 15 degrees respectively, each 24 hours thereafter. Throughout the time interval between loading and unloading, the top was the warmest part of the load. The fan car had a 15 degree spread in temperature the first night after loading, before joining the through train, and a 10, 4, 3 and 7 degree range, respectively, at each 24 hour interval thereafter, with the middle position being the warmest and the bottom layer the coldest through the greater part of the transit period. The overhead bunker car had a somewhat narrower spread in temperature than the non-fan car but a wider one than the fan car during transit. The first midnight the spread in temperature was 10 degrees and at each succeeding 24 hours was 16, 15, 16 and 16 degrees, respectively. The top of the load was the warmest throughout transit.

Rate of Cooling - The warmest part of the load in the fan car was reduced in approximately 26 hours to 60° from the loading temperature of 69° by noon of the day after loading, to 50° about 28 hours later and lowest level, 41°, the fourth night after loading. The maximum temperature in the overhead bunker car was reduced from 73°, the loading temperature, to 60° during the third night and a uniform falling of temperature reaching its lowest level, 50°, the fifth night. From the loading temperature of 67°, all of the fruit in the non-fan car reached the 60° level during the second morning after loading, 50° the fourth night and 46°, the minimum, in that position about 24 hours later.

Icing Record - The total amount of ice received by these three cars was non-fan car, 14,800 pounds, fan car, 14,400 pounds and overhead bunker car 18,700 pounds. When the three cars were unloaded the night of the 17th, the bunkers of the fan car were about 3/8 full of ice (3,600 pounds); the bunkers of the standard end bunker car were about 5/8 full (6,000), while the amount of ice in each of the ten ice bunkers of the overhead bunker car ranged from 25 to 300 pounds.

The second test was loaded at Highland City, Florida, March 28, with the double deck car being completed at 10:30 a.m., the non-fan car at 11:00 a.m., the fan car at 2:00 p.m. and the overhead bunker car at 5:30 p.m. All cars were pre-iced, shipped under Standard Refrigeration and reached the New York City area three days after loading, where they were held three days before unloading.

The fruit used was color-added, U.S. No. 1 oranges, packed mostly in eight pound open mesh bags. The loading method, except in the end bunker car with double decks, was open mesh bags over one layer of wirebound crates containing oranges. No crated fruit was placed in the double deck car which was

loaded with six layers of bags on each deck. In the other end bunker cars there were nine layers of mesh bags and ten layers in the overhead bunker car. A layer of kraft-bound excelsior pads was placed on the floor racks or crates to protect the fruit in mesh bags.

Outside Temperatures - The thermograph placed on the underside of the car to record outside air temperatures failed to operate. According to the records of the Weather Bureau, the outside air temperatures ranged from 41° to 81°. Temperatures were practically normal on March 28, 29 and 31. They were from 9 to 11 degrees above normal on the 30, and from 6 degrees below to 12 degrees above normal during the 3 day holding period in New York.

Average Commodity Temperatures - During loading, commodity temperatures, Figures 4, 5, 6 and 7, averaged 83.7° in the double deck car, 85.6° in the standard car, 84.2° in the fan car and 83.1° in the overhead bunker car. On arrival at the New York City area, 4 nights after loading, the average temperatures in these cars were 44.7°, 43.0°, 38.0° and 46.0°, respectively. Three days later when these cars were unloaded, the average temperatures were 41.3°, 39.3°, 37.7° and 42.7° respectively. During transit, the average commodity temperature was lowest in the fan car and highest in the overhead bunker car.

The top of the load, the warmest position in non-fan cars, was several degrees warmer in the double deck than in the other non-fan cars. The middle layer was the warmest part in the fan car during most of the trip between Savannah and New York. Upon arrival in the New York City area, the warmest temperatures in the non-fan cars were 53°, 49° and 48° found in the top quarter-length position of the loads in the double deck, overhead bunker and standard bunker cars, respectively, while in the fan car the warmest position, the middle quarterlength, was 40°.

Temperature Spread - The greatest spread in temperature during transit occurred in the double deck car where it was as much as 37 degrees at the first midnight; 33, 25 and 19 degrees at each midnight thereafter, while during the holding period at destination, the spread was gradually reduced to 13 degrees. The slow cooling of the top layer and fast cooling in the bottom layer at the bunker accounts for these large temperature spreads. The other end bunker non-fan car had a 21 degree spread in temperature the first midnight; 21, 17 and 13 degrees at each midnight thereafter and from 10 to 12 degree spread during the holding period. There was a spread of 13 degrees in the car with overhead bunkers at the first midnight; 15, 11 and 8 degrees on each midnight thereafter during transit, and 8, 6 and 6 degrees at each 24 hour period during the holding time.

The spread in temperature in the fan car was 25 degrees the first midnight before it had moved from its loading station, whereas it was 8, 6 and 3 degrees at each succeeding 24 hour period. During the 3 day holding period the spread, while the fans were still, increased to 5, 6 and 7 degrees, respectively.

Rate of Cooling - The cooling rates of the loads in these 4 cars can be followed in Figures 4, 5, 6 and 7. It is readily apparent that part of the load next to the bunker at the floor of the car cools fast in non-fan cars reaching 46° by the first night after loading in the double-deck car and 59° in the standard car. The top and middle layers were slow in cooling and were not below 50° in the double deck car until the 4th day after loading and the 3rd day after loading in the standard car. All of the load was below 50° in the fan car by noon of the 2nd day after loading. Temperatures were more uniformly cool in this car than in the non-fan end-bunker cars and the overhead bunker car. The overhead bunker car gave unexpected results, the bottom layer cooling faster than the top layer, but not as fast as in the end bunker cars. The overall cooling rate was about the same as in the standard end-bunker car, the load reaching 50° the 3rd day after loading.

Icing Record - Total ice received by these 4 cars was: 24,000 pounds, 25,400 pounds, 27,300 pounds and 37,100 pounds in the double deck, standard end bunker, fan and overhead bunker cars, respectively. Ice bunkers of the end bunker cars were more than half full when they were unloaded three days after delivery, while those of the overhead bunker car were about 1/5 full.

Fruit Inspection at Destination - Grapefruit - The lading of each car was free of skin breakdown and decay on arrival and the fruit had a fresh and attractive appearance. The marked packages, located at the top doorway position in each car lost 0.4 pounds in the overhead bunker car, 0.2 pounds in the fan and 1.0 in the non-fan car.

Oranges - Skin breakdown was found occasionally in all cars. Splitting was found mostly in the bottom and next to the bottom layers of bags in 3 of the 4 cars. No splitting was found in the double deck car in which the bags were piled only 6 high. About 4 times as much, 2.5 percent, was found in the overhead bunker car (highest load) as in the standard car which showed the next greatest amount. The fruit that was flattened or markedly bruised, found mostly in the two bottom layers of bags, ranged from 1.8 percent in the double deck car to 5.5 percent in the overhead bunker car. There was 4 times as much bruising in the upper deck load as in the lower. There was less than 1/2 percent decay in any of the cars.

## Discussion

In the December test with grapefruit in nailed crates, the fan car gave the most uniform temperatures as well as the most rapid reduction in temperature in the top of the load. The fan car had the entire load in the safety zone (below 50°), by midafternoon of the second day after loading, while the load in the non-fan car reached that level about 34 hours later, and in the overhead bunker car some 24 hours after the non-fan car.

The average daily commodity temperature reduction during transit was not greatly affected by low outside air temperatures beginning the third day after loading. It seems unlikely that they were of sufficient duration to have

dangerously affected commodity temperatures on arrival at the New York area had the cars been converted to Ventilation Service at Potomac Yards, yet the rate of cooling, doubtless, would have been accelerated by the incoming cold air.

Although the commodity temperature was higher in the overhead bunker car, the hourly rate of cooling in the top of the load in this car was about the the same as that in the standard end bunker car, while the bottom layer in the latter car cooled more rapidly than that in the former car during the first 2 or 3 days. Since the condition of the loads in each car was essentially the same when unloaded - all fresh and bright - the difference in temperature had little if any effect on appearance and condition of the commodity offered for sale at auction.

Upon unloading, three days after re-icing, there was enough ice in the bunkers of the cars re-iced but once to maintain satisfactory commodity temperatures for at least a day or two, perhaps longer, even with normal outside air temperatures, had it been necessary to hold these cars at destination before unloading.

In the March test with oranges mostly in open mesh bags, the fan car again gave the most uniform as well as the most rapid reduction in temperatures in the top of the load. This car had the entire load below 50° by noon of the second day after loading, while that level was reached some 26 hours later in the standard car and several hours still later in the overhead bunker car at or near Potomac Yards, yet this level was not reached in the double deck cars until they had reached the New York area 4 days after loading.

Fruit splitting and bruising, due to superimposed weight, was confined to the 2 bottom layers of bags. While no splitting occurred in the double deck car with its 6 layers, there was about 1.8 percent splitting in the overhead bunker car with 10 layers of bags and about 1/9 that amount in the cars with 9 layers of bags. The greatest amount of bruising, 5.5 percent, was found in the overhead bunker car, while in the double deck car there was approximately 2.0 percent bruising, which was 4 times more prevalent in the upper deck as the lower.

The transit temperatures in these shipping tests followed the same general trend as those obtained in the ARA-USDA, No. 1 test, a transportation test with crated grapefruit loaded May 2, 1946. The top of the load temperatures in the non-fan, fan and overhead bunker cars for this test and the two discussed in this report are shown in figure 8.

## Summary

In neither of these shipping tests did the overhead bunker give indication of vast superiority over the non-fan end bunker car when appraised on the basis of speed of temperature reduction during transit. The end bunker fan car cooled the load faster and more uniformly than the non-fan cars. These findings confirm the ARA-USDA, No. 1 test. Injury to bagged fruit during transit, while negligible in the 6 layer load, increased with the depth of the load.

## Acknowledgments

These tests were made possible by the generous cooperation of the transportation, shipping and receiving agencies and their several respresentatives. Acknowledgment is due the Atlantic Coast Line Railroad, the Florida East Coast Railway and Fruit Growers Express Company; also the American Fruit Growers Inc., Atlantic Commission Co., J. S. Barnes and Co., Deerfield Groves and Co., and Florida Citrus Exchange.

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| L. E. Siebert, Agent | Lakeland, Florida |

Figure 1

Top Doorway ————
Middle Quarterlength — — — TEMPERATURE IN TRANSIT
Bottom Bunker —O—O— Standard End Bunker Car
FGEX 38230

Pre-iced, Item 80,
Section 2
Re-iced Waycross, P1VC
542 Crates

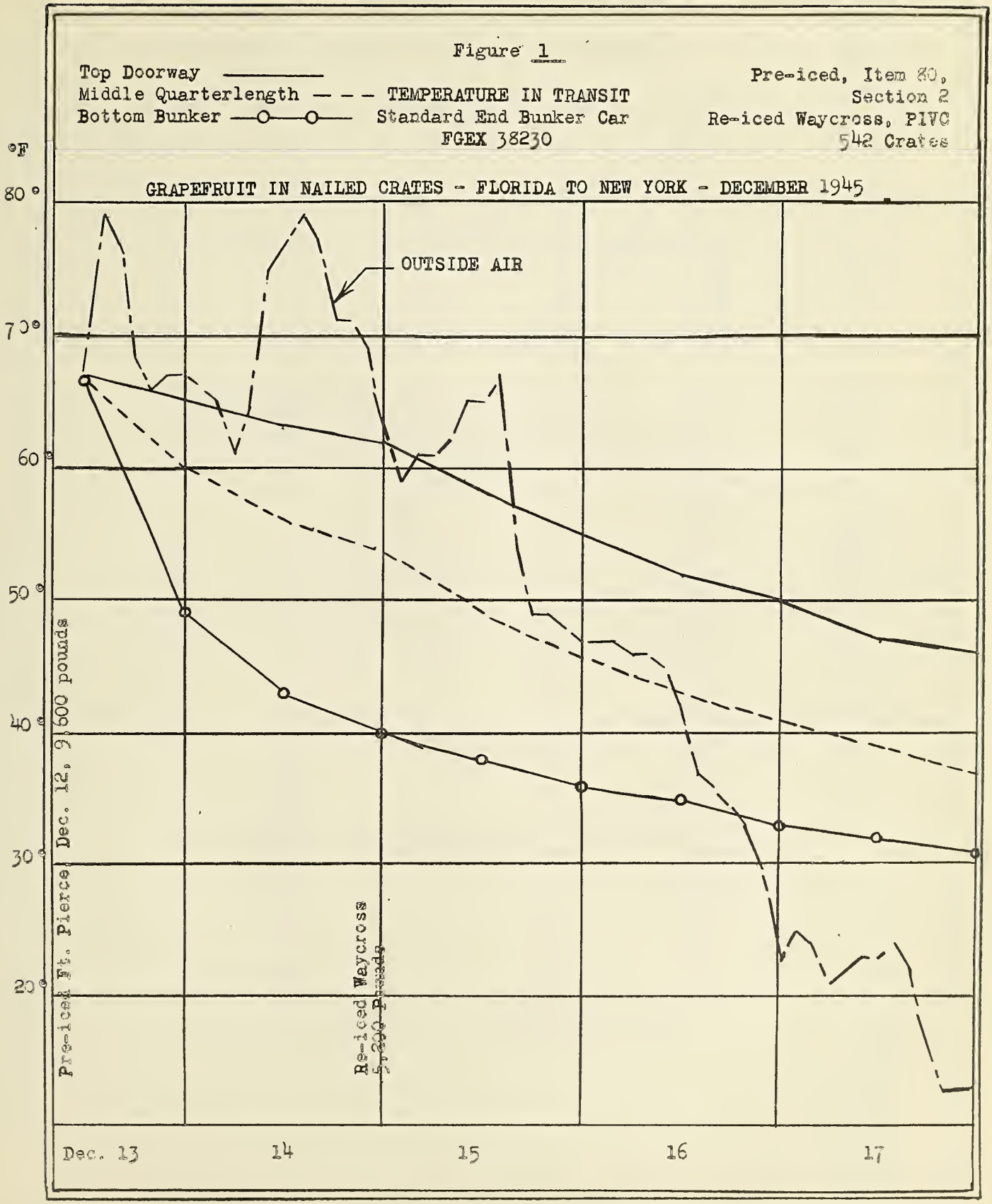


Figure 2

Top Doorway ————————
Middle Quarterlength — — — —
Bottom Bunker ——o——o——

TEMPERATURE IN TRANSIT
Standard End Bunker Car with Floor Fans
BREX 74673

Pre-iced, Item 80, Section 2
Re-iced Waycross, PIVC
536 Crates

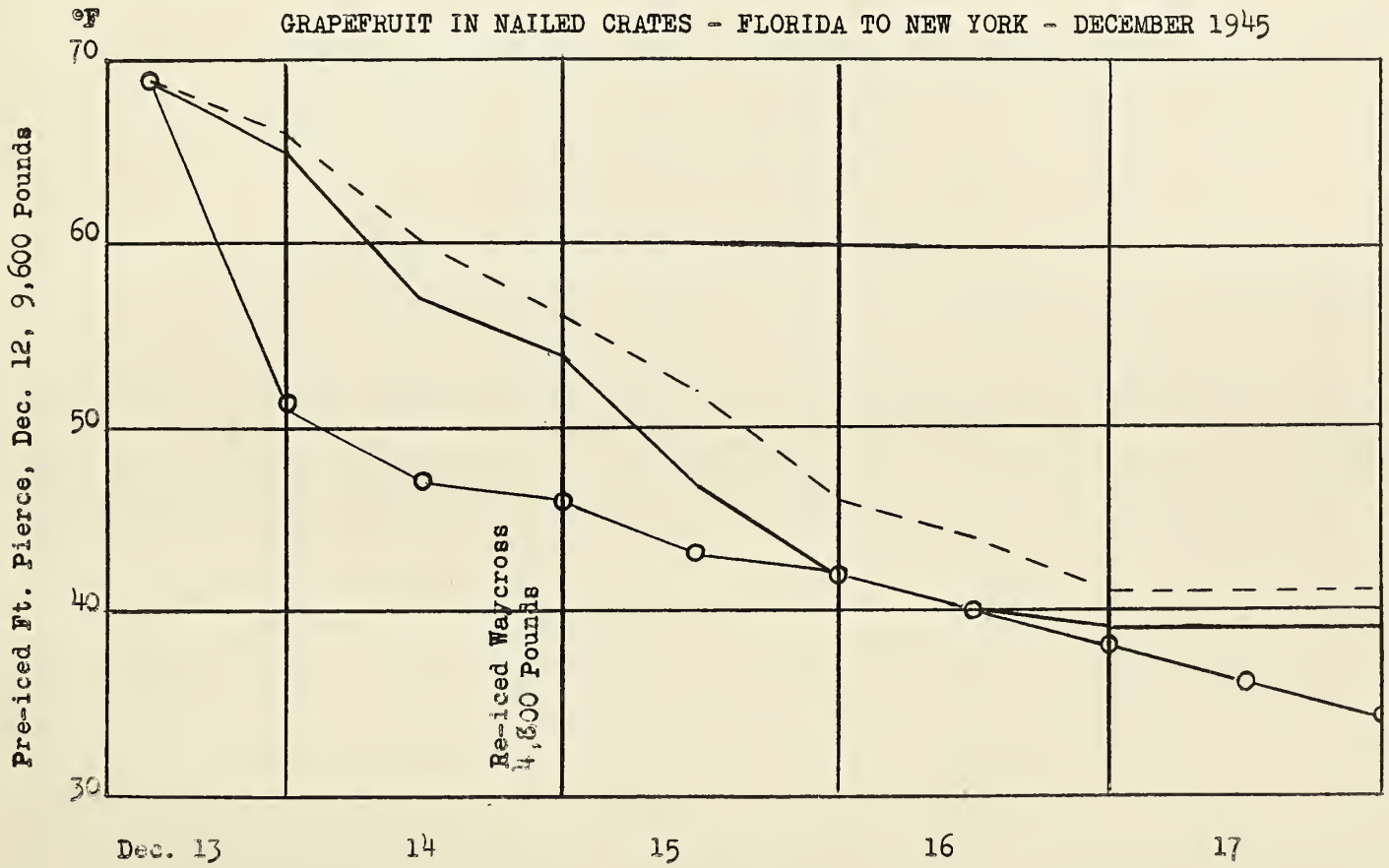


Figure 3

Top Doorway ————
Middle Quarterlength - - - -
Bottom Bunker —o—o—

TEMPERATURE IN TRANSIT
Overhead Bunker Car
FOBX 4108

Pre-iced, Item 80, Section 2
Re-iced Waycross, PIVC
820 Crates

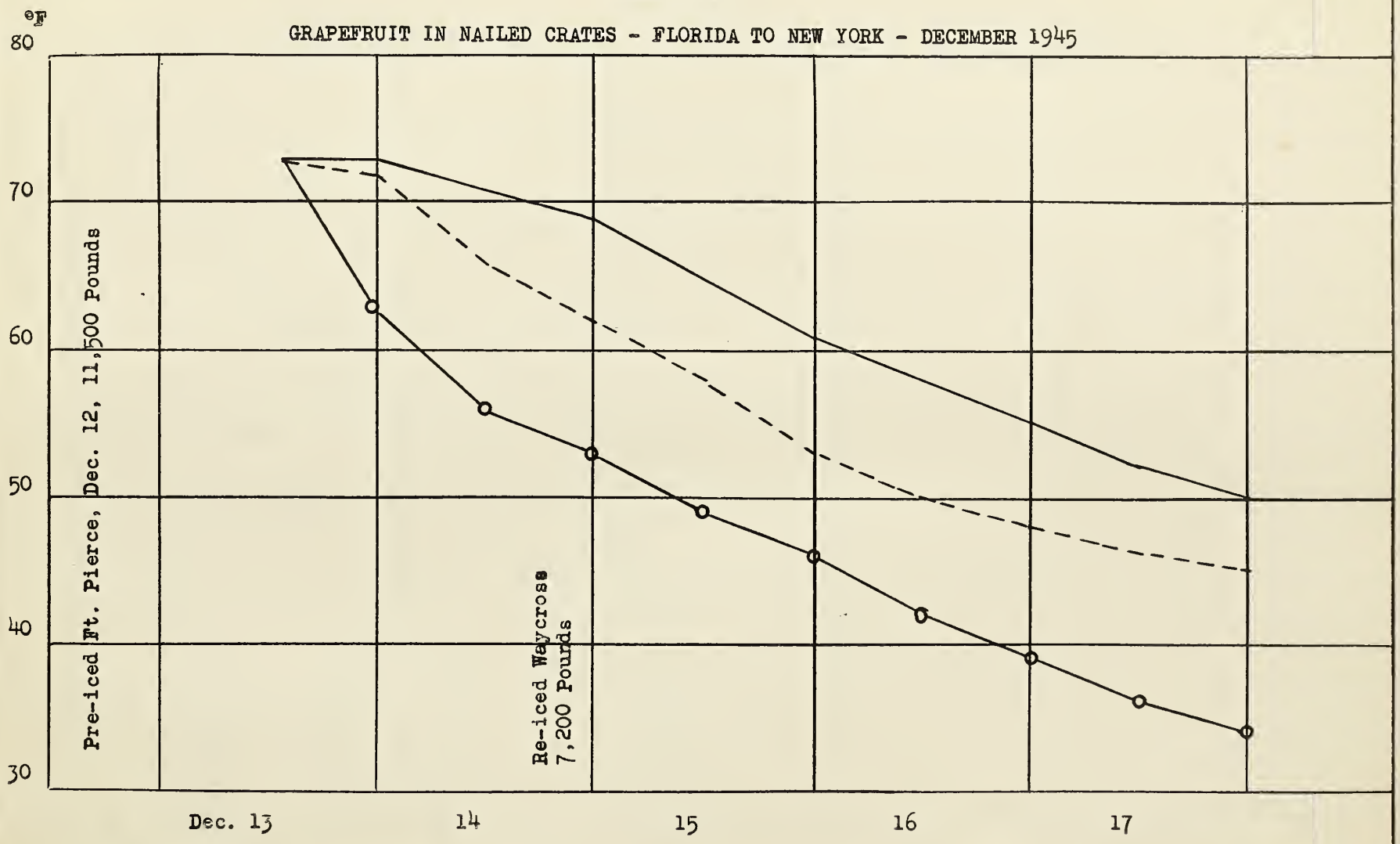


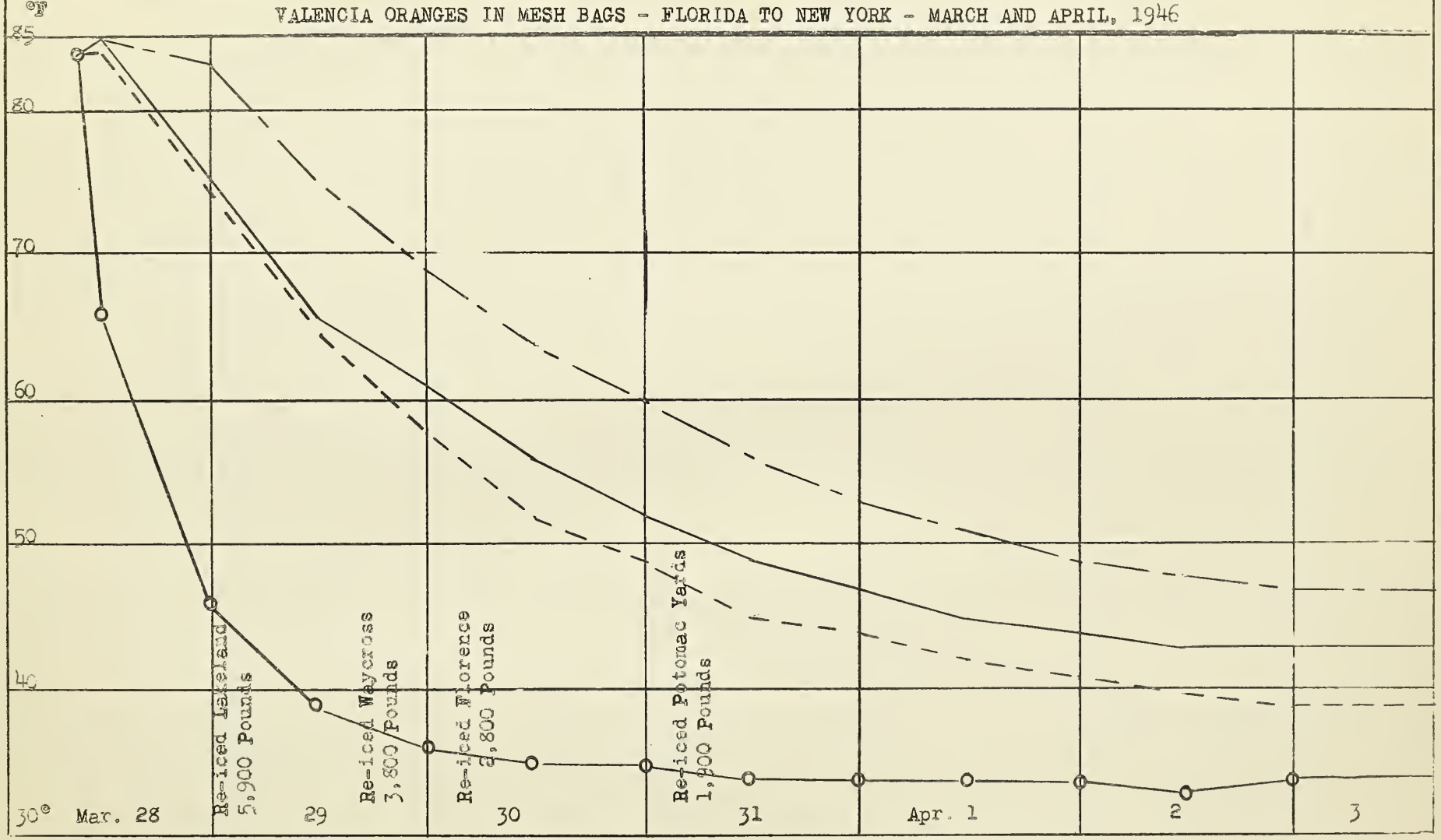
Figure 4

Top Doorway
Top Quarterlength
Middle Quarterlength
Bottom Bunker

TEMPERATURE IN TRANSIT
Non-fan Double Deck
FDEX 9290

Pre-iced, Standard Refrigeration
4,600 8 Pound Open Mesh Bags

VALENCIA ORANGES IN MESH BAGS - FLORIDA TO NEW YORK - MARCH AND APRIL, 1946



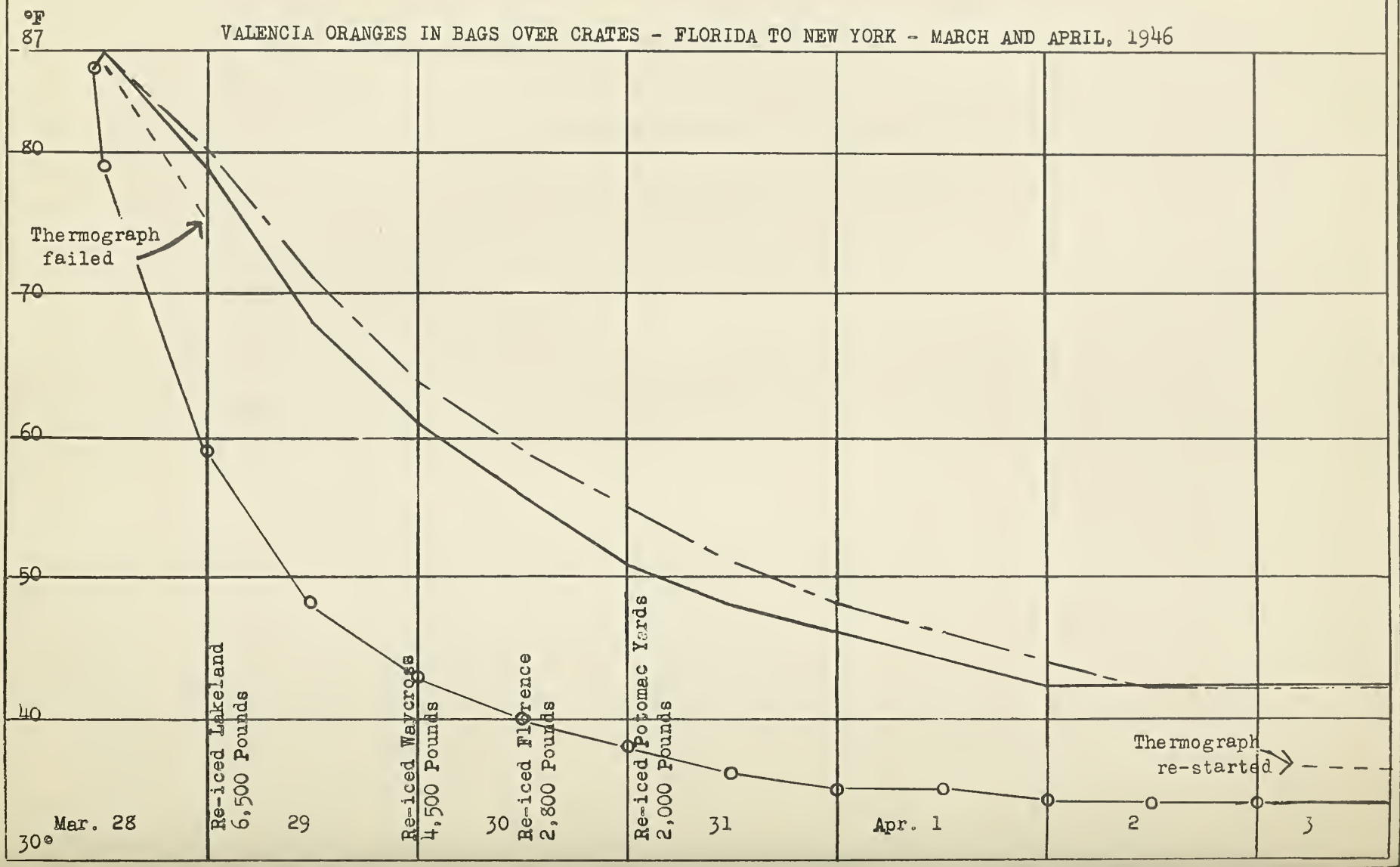

Pre-iced Lakeland, Mar. 27, 9,600 Pounds

Figure 5

TEMPERATURE IN TRANSIT
Standard End Bunker Car
FGEX 38122

Top Doorway ——————
Top Quarterlength —— - —— -
Middle Quarterlength — — — — —
Bottom Bunker ——o——o——

Pre-iced, Standard Refrigeration
105 Wirebound Crates
3,500 8 Pound Open Mesh Bags




Pre-iced Lakeland, Mar. 27, 9,600 Pounds

Figure 6

Top Doorway ————————
Top Quarterlength —— - —— -
Middle Quarterlength – – – – –
Bottom Bunker ——o——o——

TEMPERATURE IN TRANSIT
Standard End Bunker Car with Floor Fans
BREX 74644

Pre-iced, Standard Refrigeration,
Fan Service
105 Wirebound Crates
3,500 8 Pound Open Mesh Bags

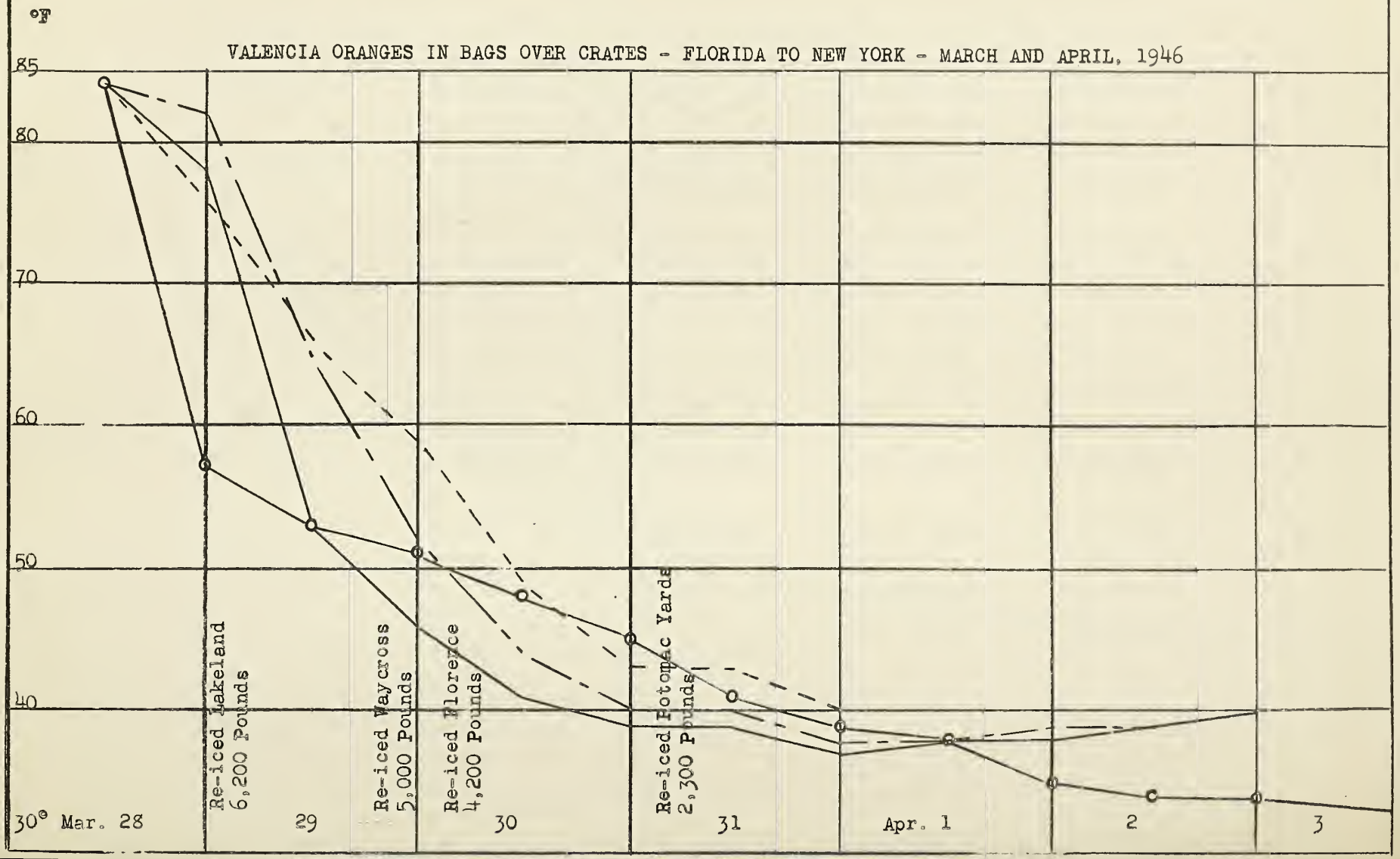


Figure 7

Top Doorway ——————
Top Quarterlength – ———— – ———
Middle Quarterlength – – – –
Bottom Bunker ——o——o——

TEMPERATURE IN TRANSIT
Overhead Bunker Car
FOBX 4155

Pre-iced, Standard Refrigeration
169 Wirebound Crates
6,000 8 Pound Open Mesh Bags

VALENCIA ORANGES IN BAGS OVER CRATES - FLORIDA TO NEW YORK - MARCH AND APRIL, 1946

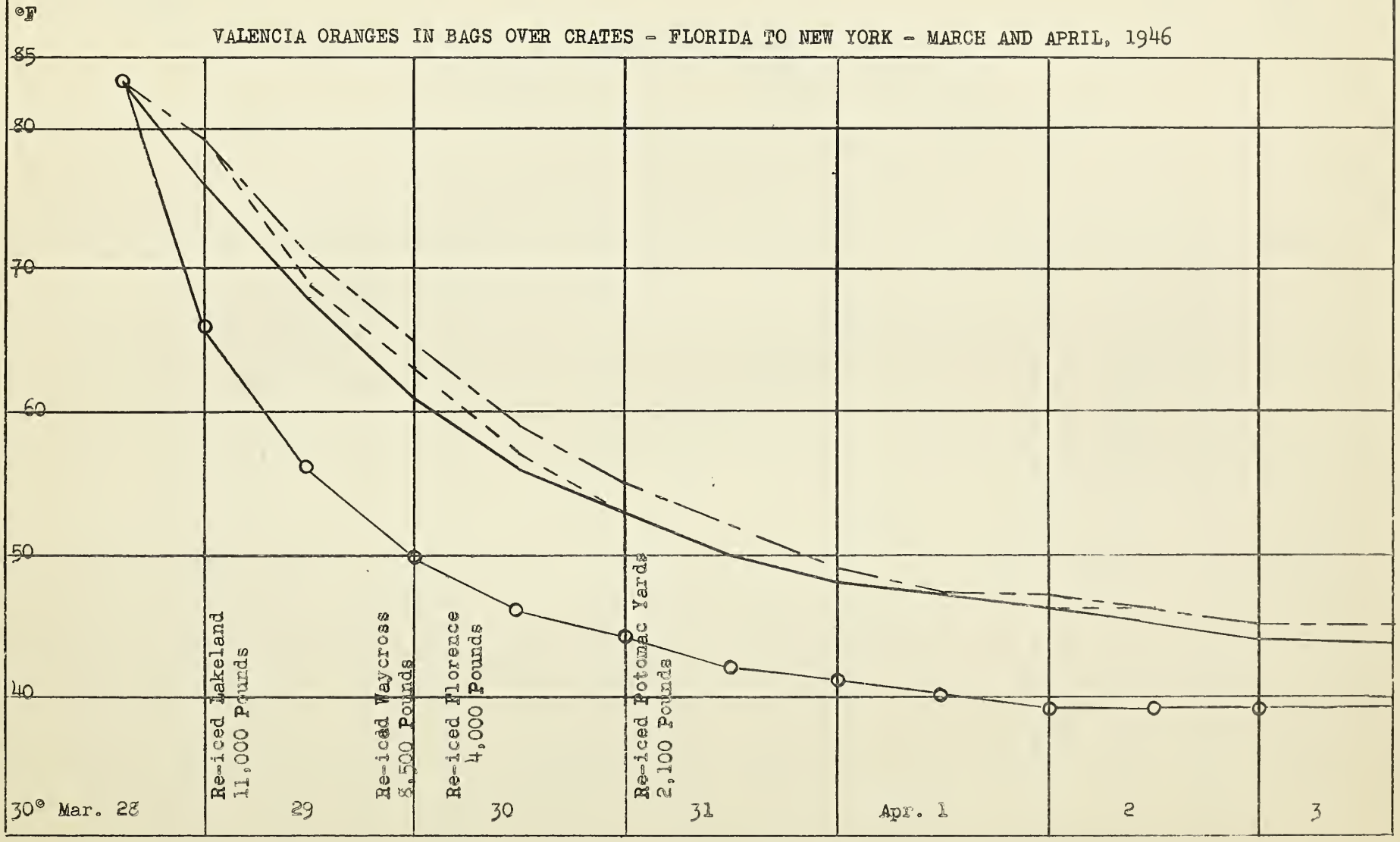


Figure 8

Standard End Bunker Car ————————
End Bunker - Fan Car ——o——o——
Overhead Bunker Car — — — — — —
MT = Midnight

TEMPERATURE IN TRANSIT
Top Of Load

Comparison of Cars
December
March - April
May

Protective Service
Item 80, Section 2
December

Standard Refrigeration
March - April, May